Burrow-use by herpetofauna of the Werribee–Keilor plains

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Abstract

Instances of herpetofauna from the Werribee-Keilor (basalt) plains using burrows, either self-constructed or made by other organisms, are described. Eleven species, eight reptile and three frog species, were recorded using burrows as refugia. Of these, six species were found to occupy burrows made by invertebrates, mammals and other reptiles while eight species were found to construct their own burrows. A close association between two burrowing skinks, the Eastern Striped Skink *Ctenotus robustus* and Southern Lerista *Lerista bougainvillii*, and the occurrence of Corangamite stony loam soil is identified and discussed. (*The Victorian Naturalist*, 131 (3), 2014, 72–83)

Keywords: burrows, basalt plains, soil, herpetofauna

Introduction

The herpetofauna of the Werribee–Keilor (basalt) plains situated to the north and west of Melbourne make extensive use of abundant surface stone and the network of cracks and cavities that form in the region's clay soils (Brereton 1991; Larwill 1995; pers. obs.). By contrast, relatively few reptile or frog species inhabiting the plains are reported to construct or otherwise use burrows made by other organisms. In this work I detail observations on the type and frequency of burrow-use by herpetofauna of the Werribee–Keilor plains and examine its relationship to soil-type.

Methods

Observations occurred during the years 1990–1996 inclusive in grassland remnants of the Werribee–Keilor plains whilst conducting searches for reptiles and frogs. Searches took place mostly by day and involved the visual inspection of potential basking sites, the examination of surface burrows and the base of grass tussocks and stones, and by lifting surface stones and other potential refugia. All sites were located within 30 km of the Melbourne CBD. Suburban locations where observations occurred included: Mernda, Mill Park, Bundoora, Thomastown, Somerton, Craigieburn, Broadmeadows, Sunshine, Deer Park, Ardeer, Derrimut, Altona and Werribee. Many of the remnant grasslands at these localities have since been greatly reduced in size, degraded or else have been destroyed in their entirety due to the expansion of urban and/or industrial developments. A few grasslands, such as those at Craigieburn and Altona, survive as larger reserves.

Observations occurring at only one or two particular localities are indicated; other observations may be assumed to have occurred at three or more separate localities. Reference to the 'adult' size-class below is based on the 'average' adult sizes given in Cogger (2000) for reptiles and Barker *et al.* (1995) for frogs; the 'subadult' and 'juvenile' size-classes are inferred from these. Snout-to-urostyle lengths (SULs; ±0.02 mm) and snout-to-vent lengths (SVL; ±1 mm) were measured; total lengths (TLs) exceeding 500 mm were estimated to the nearest 0.1 m; the maximum linear dimensions of refuges and/or burrows were measured to the nearest 5 mm. Where possible, the sex of individuals was identified. In some instances, not all details were recorded in order to minimise disturbance or because of time constraints.

For the purposes of this work, a 'burrow' is defined as a subterranean cavity or passage made by some organism. While burrow excavation was rarely witnessed, indirect signs that a burrow had been made by some organism, rather than being naturally formed, was indicated primarily by its shape, evidence of digging and also through consulting published descriptions of the burrows made by particular organisms (if known). Also, the consistent association of the same organism with the same burrow-type is indicative of their having made it. Naturally formed 'burrows' that had been modified through occupancy could not be distinguished from those constructed in their entirety by an organism.

Nomenclature used below largely follows Cogger (2000) with a few exceptions, namely the correction of the specific name of the frog *Neobatrachus sudelli* to *N. sudellae* (Shea 2012), the use of the common name given in Barker *et al.* (1995) for this species and also for the frog *Litoria raniformis*, and the generic repositioning of the snake *Suta flagellum* to *Parasuta flagellum* in Wilson and Swan (2010) and other recent publications.

Site Description

The Werribee–Keilor plains consist predominantly of four soil types: three soils with uniform texture: Corangamite stony loam, Grenville and Mooleric clays and a fourth with (alkaline) duplex texture: red-brown clay loam of the Werribee plains (Leeper 1982; Cochrane *et al.* 1991). Of most relevance to this work are differences in clay content rather than soil texture and thus I distinguish two basic soil types: those with high clay content (Grenville, Mooleric and red-brown clay loam) and those with low clay content (Corangamite stony loams). Grenville clays typically occur on slopes and plains beyond the influence of the stony rises while Mooleric clays typically occur in between and around the base of stony rises (Baldwin 1950). They are both grey to black in colour and are common in grasslands north of Melbourne (e.g. Bundoora, Craigieburn, Mernda). The Corangamite stony loam soil is confined largely to stony rises and cliffs/escarpment lining creeks. It is a friable brown loam that is high in organic matter and typically shallow (it is hereafter referred to as 'friable loam' or simply 'loam' soil). At all localities, clay soils were dominant, though they varied in physical structure and colour depending on the site, and there was also significant variability within some sites. The red-brown clay soils occurred mainly on the Werribee plains to the west of Melbourne (e.g. Ardeer, Deer Park, Rockbank and Sunshine). The high clay content of basalt plains soils leads to a significant contraction when dry (approximately 13% of its area; Patton 1935) which is most apparent in summer and autumn (Sutton 1916; pers. obs.). Cochrane *et al.* (1991) stated that the greatest movements occur in dark clays formed on basalt of the West Victorian Volcanic Plains, which takes in most of Melbourne's western suburbs and much of the Western District. The friable loam soils associated with stony rises do not exhibit such movements because of their much lower clay content (Patton 1935).

Observations

Species recorded using burrows made by other organisms

Six species were recorded using burrows made by other organisms (Table 1 contains details of some particular instances). In all cases, other organisms had recently occupied the burrow (<12 months prior) and in several instances (such as observations 1 and 3) still occupied the burrow.

1. Yabbie burrows: Four instances of the Southern Water Skink *Eulamprus tympanum* and six instances of the Spotted Grass Frog *Limnodynastes tasmaniensis* using Yabbie *Cherax destructor* burrows were recorded (Table 1). Yabbie burrows were bored into clay soil, often around the base of sedges, the edges of well-embedded stones and also beneath surface stones. Most instances of lizards and frogs occupying yabbie burrows were observed when stones were lifted revealing the burrows beneath (eight of 10). *Eulamprus tympanum* were observed either a short distance down the burrows or else were at rest on the soil beside the stone and, upon being disturbed, retreated beneath the stone and down into the burrow. In several instances, skinks retreated down into water-filled burrows and completely submerged themselves. All *L. tasmaniensis* were observed down moist or water-filled burrows. The adults and juveniles of this species have a tendency to form small aggregations beneath surface stones when there is sufficient moisture (pers. obs.; Johnson 1969); three of the observations of this species involved small aggregations of frogs occupying the same burrow (Table 1). Yabbies were observed occupying these same burrows at other times of the year. All of the above observations occurred 25–40 m from Merri Creek at Craigieburn (144°58'E,

Table 1. Some instances of basalt plains herpetofauna using burrows made by other organisms. Abbreviations SUL = Snout-to-urostyle length, SVL = Snout-to-vent length, TL = Total length (tip of snout to tip of tail).

Date	Species	Organism	Details
10/6/90	Southern Water Skink *Eulamprus t. tympanum*	Yabbie burrow	Small adult retreated down a burrow with circular entrance ≈ 25 mm diameter and depth >15 cm in damp clay beneath a stone.
14/4/91		Yabbie burrow	Two sub-adults located at the opening of burrows with circular entrances ≈ 20 mm diameter in moist clay and depths >15 cm beneath separate stones; water in both burrows.
28/9/96		Yabbie burrow	Adult retreated down a burrow with circular entrance ≈ 25 mm diameter in moist clay and depth >10 cm located beneath a 0.35 × 0.22 × 0.12 m stone.
3/8/91	Spotted Grass Frog *Limnodynastes tasmaniensis*	Spider burrow	Sub-adult SUL 25 mm located ≈ 30 mm down vertical burrow with circular entrance ≈ 15 mm diameter in moist clay at base of tussock; burrow depth >7 cm.
3/8/91		Yabbie burrow	Two adult ♂s SULs 34, 38 mm, one adult ♀ SUL 38 mm in direct body contact 10–30 mm down burrow with circular entrance ≈ 25 mm diameter in clay; water in burrow.
7/8/93		Yabbie burrow	Two small ♀s SUL 30 mm for both; 30–50 mm down burrow with circular entrance ≈ 25 mm diameter in moist clay; water in burrow.
1/7/95		Yabbie burrows	Sub-adults (n = 3 together in one burrow) and adults (n = 2, separate burrows); all burrows with circular entrances ≈ 20 mm diameter in moist clay beneath stones.
6/7/91	Eastern Blue-tongued Skink *Tiliqua s. scincoides*	*Mus musculus* burrow	Juvenile SVL 145 mm curled-up in remnants of grassy nest in cavity with a single-entrance beneath 0.45 × 0.35 × 0.25 m stone on clay soil.
14/9/91		*Mus musculus* burrow	Adult SVL 290 mm curled-up in large multiple-entrance cavity beneath 0.76 × 0.58 × 0.15 m stone on clay soil.
13/6/92		*Mus musculus* burrow	Adult SVL 250 mm curled-up in large depression with a single-entrance beneath 0.36 × 0.33 × 0.10 m stone on clay soil.
3/7/93		*Mus musculus* burrow	Adult SVL 243 mm curled-up in grass nest of *T. triandra* leaves in large cavity with beneath 0.49 × 0.33 × 0.14 m stone on clay soil.
10/4/94		*Mus musculus* burrow	Juvenile SVL 156 mm curled-up in a spherical grass nest in a large single-entrance cavity with beneath 0.47 × 0.24 × 0.19 m stone on clay soil.
14/9/91		*Sminthopsis crassicaudata* burrow	Adult SVL 290 mm in single-entrance cavity with hemispherical grass nest of *Themeda triandra* leaves beneath 0.76 × 0.58 × 0.15 m stone on moist clay soil.
28/1/92		*Sminthopsis crassicaudata* burrow	Adult SVL 285 mm in remnant grass nest in cavity with two entrances beneath 0.27 × 0.23 × 0.15 m stone on dry clay soil.
13/6/92		*Sminthopsis crassicaudata* burrow	Juvenile SVL 160 mm curled-up in a single-entrance burrow beneath a well-imbedded stone 0.43 × 0.27 × 0.12 m on clay soil.
11/8/91	Eastern Brown Snake *Pseudonaja t. textilis*	*Mus musculus* burrow	Sub-adult TL ≈ 1 m in single-entrance cavity beneath stone 0.48 × 0.47 × 0.14 m on damp clay soil.

Table 1. cont.

Date	Species	Organism	Details
16/2/91		*Mus musculus* burrow	Adult TL ≈ 1.2 m retreated into circular en trance hole ≈ 45 mm diameter leading to large cavity beneath stone 1.0 × 0.8 × 0.4 m on loam soil.
12/2/94		Rodent burrow	Adult TL ≈ 1.5 m retreated into circular (40 mm diameter) hole at base of escarpment in clay soil; two other entrances nearby (< 0.5 m).
29/8/96		*Tiliqua s. scincoides* burrow	Adult TL ≈ 1.2 m in a single-entrance cavity beneath a large stone in clay soil.
24/6/95	Eastern Tiger Snake *Notechis scutatus*	*Tiliqua s. scincoides* burrow	Adult TL ≈ 1.0 m beneath stone located 1.2 m from a dry-stone wall on moist clay soil.
24/6/95		*Mus musculus* burrow	Juvenile TL ≈ 0.3 m in a cavity with remnant grassy nest beneath stone in dry clay soil.

37°38'S) in what now forms part of the Craigieburn Grasslands Reserve.

2. Spider burrow: One instance of a sub-adult *L. tasmaniensis* occupying an abandoned Wolf Spider *Tasmanicosa* sp. (Lycosidae) burrow in clay soil was recorded (Table 1). This observation occurred just south of the Craigieburn Grasslands Reserve.
3. Small mammal burrows: Both juvenile and adult Eastern Blue-tongued Skinks *Tiliqua scincoides scincoides* have been observed using burrows made by the House Mouse *Mus musculus* (n=5; Fig. 1) and the Fat-tailed Dunnart *Sminthopsis crassicaudata* (n=3) (Turner 2010). In most of these instances, *T. s. scincoides* was found occupying a nest which months earlier, or sometimes the previous winter, had been occupied by either of these species. Additional records of *T. s. scincoides* occupying mouse nests/burrows (n=4) could not be confidently assigned to either species. All burrows had relatively narrow (<50 mm width) entrance tunnels through clay soil beneath stones, leading to larger cavities in which the stone formed the roof of the cavity; occasionally there were multiple entrances. The spherical grass nests of *M. musculus* and *S. crassicaudata* located in depressions beneath stones were sometimes occupied by overwintering *T. s. scincoides* (n=3) and also by juvenile Eastern Brown Snakes *Pseudonaja textilis textilis* (n=2) and a juvenile Eastern Tiger Snake *Notechis scutatus* (n=1). Adult *P. t. textilis* (n=3) and an adult *N. scutatus* (n=1) were observed retreating down what appeared to be rodent burrows on being disturbed. These burrows had inverted U-shaped entrances, approximately 30–50 mm both in width and height, bored into clay soil along eroded creek banks. Furthermore, both species were observed occupying burrows and cavities beneath stones previously occupied (and presumably constructed by) *M. musculus* (n>15; details of five instances are in Table 1). Hoser (1991) documents an aggregation of six adult *P. t. textilis* unearthed at Melton Airport apparently occupying a subterranean cavity with no obvious entrance.
4. Reptile burrows: Two instances of juvenile *P. t. textilis* occupying burrows previously made by adult Eastern Striped Skink *Ctenotus robustus* (see below) beneath stones on loam soil were recorded. At least three instances of adult *P. t. textilis* and one instance of a juvenile *N. scutatus* occupying burrows beneath stones made by adult *T. s. scincoides* the previous winter were also recorded (Table 1). There were at least 15 instances of both juvenile and adult Little Whip Snakes *Parasuta flagellum* being located in burrow cavities beneath stones that were previously occupied by adult *C. robustus*.

Species that construct burrows

Eight species were recorded occupying burrows that they apparently had constructed (Table 2):

1. Burrows of Sudell's Frog *Neobatrachus sudellae* were occasionally observed beneath or around the edges of stones especially following heavy rain (n=18). These burrows were

Fig. 1. An adult Eastern Blue-tongued skink *Tiliqua scincoides scincoides* (partly visible left of centre) in situ in a single entrance over-wintering burrow (approximate outline shown) excavated beneath a stone resting on clay soil. Much of the burrow cavity is filled with dried Kangaroo Grass *Themeda triandra* leaves and was occupied by Fat-tailed Dunnarts *Sminthopsis crassicaudata* earlier in the year.

typically vertical, 70–100 mm depth, and with a distinctive neat circular opening 20–30 mm diameter (Fig. 2). Sometimes adult frogs were located at the bottom of burrows (n=8). It was common to observe two or three such burrows beneath the same stone, perhaps indicating repeated use of the stone by frogs (n=4). Burrows were located mostly in loam soil on stony rises but others were in clay soil. No other reptiles or frogs were observed occupying *N. sudellae* burrows. Two *N. sudellae* were (accidentally) unearthed from burrows 150–200 mm deep in hard clay soil during summer.

2. Adult and sub-adult Eastern Banjo Frogs *Limnodynastes dumerillii dumerillii* were observed occupying shallow burrows and soil depressions of their own making beneath stones (n=11) in a variety of soils. In one instance a sub-adult (SUL 25 mm) was located beneath a 0.52 × 0.45 × 0.15 m stone in a shallow depression in moist loam soil. A similar depression was located a few centimetres away. One specimen was unearthed from a burrow approximately 100 mm deep in hard clay soil during summer.
3. *Ctenotus robustus* were commonly observed using burrows that consisted of cavities with one or two narrow entrances excavated in loam soil beneath stones (n=28). Burrows did not extend vertically down into the soil to any significant extent (<5 cm) but instead extended horizontally beneath the stone sometimes to matted-grass roots around the edges of the stone, and some burrows extended to adjoining stones. Burrows had either a single or multiple (up to three) entrances at the edge of the stone. There was much variability in burrow shape, which in most instances seemed to be limited by shallow soil or by the convexity of the stone. All except one individual were beneath stones resting directly on loam soil (62 of 63; 98%); the exception was a burrow excavated in a small soil accumulation between exfoliating basalt stones. There was a significant association between size-class and burrow construction, with adults tending to construct

Table 2. Herpetofauna from the Werribee-Keilor plains that construct burrows. The number of occurrences of burrowing in each species is given (n).

Species	*n*	Burrows: shape and substrate-type.	Comments
Eastern Banjo Frog *Limnodynastes d. dumerillii*	11	Shallow depressions beneath stones and vertical burrows in clay or loam soil.	Habitual burrower; occasionally located in shallow depressions following heavy rain.
Sudell's Frog *Neobatrachus sudellae*	18 (only 8 occupied)	Single entrance vertical burrows with neat circular openings in moist clay or loam soil.	Habitual burrower; occasionally located beneath surface stones in burrows following heavy rain.
Eastern Striped Skink *Ctenotus robustus*	52	Shallow burrows with single or multiple entrances leading to a cavity in loam soil.	Adults are habitual burrowers beneath surface stones on stony rises or escarpment; juveniles occupy shallow depressions beneath surface stones.
Southern Lerista *Lerista bougainvillii*	85	Sub-surface tunnels and cavities in loam soil.	Fossorial in habit; located in burrows and depressions both beneath, and also away from, surface stones.
	17	Typically single-entrance burrows with a large cavity beneath surface stones in clay or loam soil.	Often burrows to gain access beneath surface stones where they over-winter; some burrows appear to be used repeatedly as refuges at other times of the year.
Cunningham's Skink *Egernia cunnninghami*	14	Single- or multiple-entrance burrows with a large cavity; burrows extend beneath or between surface stones just below ground level in clay or loam soil.	Rarely burrows except to gain access beneath large stones forming escarpment or beneath stones along dry-stone walls.
Striped Legless Lizard *Delma impar*	2	Single-entrance burrows with cavities in clay soil.	Possibly a habitual burrower, hut also utilises natural soil cavities and surface stones as refugia.
Little Whip Snake *Parasuta flagellum*	8	Single-entrance burrows and cavities beneath surface stones in loam (or sandy) soil.	Rarely burrows; all instances were beneath stones on stony rises or stones forming escarpment; also uses natural soil cavities.

Fig. 2. Three burrows of the Sudell's Frog *Neobatrachus sudellae* located beneath and near the edge of a stone resting on moist clay soil; the burrow on the left was occupied by an adult frog.

Fig. 3. Three Eastern Striped Skinks *Ctenotus robustus*, an adult and two juveniles, in situ beneath a stone resting on loam soil. The adult occupies a large cavity with two entrances (approximate outline shown) while the two juveniles occupy shallow depressions.

burrows and sub-adults/juveniles occupying shallow soil depressions or else no deformation of the soil surrounding individuals was evident (2×2 contingency table with Yate's correction for continuity; $\chi^2=12.46$, 1 df, $P=0.0004$). While most *C. robustus* occurred singly beneath stones, there were some instances of multiple lizards occurring beneath the same stone during months of inactivity, though never in direct body contact: one adult and two juveniles (Fig. 3), two adults and one juvenile, one adult and one juvenile, and three instances of two juveniles.

4. Nearly all individuals (comprising all size-classes) of the fossorial skink Southern Lerista *Lerista bougainvillii* were encountered partially or completely concealed in soil cavities beneath surface stones (including well-embedded stones) where they occupied burrows which extended across the soil surface beneath the stone and down deeper into the soil (10–15 cm). Individuals were also unearthed 10–20 mm below the soil surface in loose friable loam exposed to direct sunlight (n=18). They were frequently encountered during summer months, concealed 10–20 mm below the soil beneath well-exposed surface stones (n>40). A total of 83 of 85 (97%) individuals were located in loam soil; the two exceptions were located in dry friable black clay soil with loam soil located only metres away. They were not recorded at all on the red clay duplex soils of Deer Park and Altona grasslands. The extent of *L. bougainvillii* burrows is unclear but they appear, at least in some cases, to be quite extensive, with some having been excavated over horizontal distances exceeding 60 cm.
5. Cunnningham's Skinks *Egernia cunninghami*, being saxicolous in habit, were rarely observed to use burrows (<5% of all encounters) and were therefore most frequently found occupying stone crevices in escarpment, dry-stone walls and stone piles. Adults were observed using burrows with well-worn entrances at the base of large stones forming escarpment but in most cases these did not extend significantly below ground level (n=9). They were seen at or near burrow entrances and would retreat into burrows when approached. Their scats were frequently located near entrances and along the base of escarpment and outcrops, indicating frequent and/or repeated use. Three adult *E. cunninghami* were located singly beneath stones resting directly on soil, having excavated a short (<0.2 m) single-entrance burrow, terminating in a large cavity. Several adults were observed to use natural hollows/cavities in large fallen, decaying River Red Gums *Eucalyptus camaldulensis* in northern grasslands. Two instances of adult *E. cunninghami* using underground cavities formed by large stones packed around underground water pipes on grassland fringes were recorded. Burrowing was also observed in a captive colony of *E. cunninghami* maintained under natural conditions with burrows being dug up to 40 mm below ground level through clay soil beneath stones that formed part of a stone pile which lizards used as a retreat.
6. *Tiliqua s. scincoides* of all sizes were found to have dug through clay and loam soil to gain access to existing cavities, or else excavated cavities beneath stones. These instances represent 22% of all individuals located beneath ground cover (17 of 77). The appearance of over-wintering skinks 'caked' in dry clay or loam, particularly on the head and forelimbs, was consistent with the occurrence of excavated access tunnels and/or cavities beneath stones where skinks resided (n=13; Turner 2010). In some instances individuals appeared to have simply enlarged existing gaps and depressions between the surface stones and surrounding soil. Burrows typically had a single entrance with skinks curled up in the cavity, tail curled around to near the head and typically pointing towards the entrance. The stone formed the roof of the cavity in all instances, though often a soil 'over-hang' was evident around the edge of the cavity. In four instances two entrances were clearly visible.
7. Two instances of Striped Legless Lizards *Delma impar* occupying burrows were recorded, representing 11% of all occurrences of this species beneath ground cover (two of 19). Both records were of single-entrance burrows beneath surface stones on clay soil: (i) an adult (≈200 mm total length) with head/anterior body protruding from a hole only slightly wider than the head in clay soil be-

neath a 0.20 × 0.10 × 0.06 m stone (ii) a juvenile (≈100 mm total length) had just its head protruding from a small hole (only slightly wider than the width of its head; ≈5 mm) beneath a small stone (0.08 × 0.04 × 0.01 m). All other *D. impar* located beneath stones occupied shallow soil depressions or small cavities. All individuals were from localities on duplex red clay soils.

8. *Parasuta flagellum* were observed to burrow directly into soil beneath stones on only eight occasions, representing less than 2% of all occurrences beneath ground cover (eight of 522). In all eight instances, burrows were in loam soil. In one particular instance the same adult snake was found occupying a single-entrance burrow beneath a stone for at least 2.5 months during winter; it retreated down into the burrow each time the stone was lifted. In two other instances the head and anterior body of the snake was protruding from the burrow and immediately withdrawn down into the burrow when the stone was lifted. Two of the burrows were approximately 50 mm in depth. In another three instances the species was found occupying cavities formed in between sub-surface stones and surrounding loam soil (at depths of 10–15 cm) with a single entrance hole located at the surface. Typically this species was located beneath surface stones lying directly on the soil surface, sometimes in shallow depressions or soil cavities or else were located in basalt exfoliations. In captivity, both adults and juveniles maintained in an enclosure with approximately 150 mm depth of the same loam soil would readily burrow, leaving neat circular openings on the surface leading down to the bottom of the enclosure where they occupied small cavities which they had apparently made.

Discussion

Most species of reptiles and frogs inhabiting Werribee–Keilor plains grasslands occupy gaps and cavities beneath surface refugia (i.e. stones), especially during the winter months when activity is minimal or has ceased entirely. During the warmest months it appears that many of these surface refugia are rendered unsuitable due to high day-time temperatures and/or dryness (Turner 1989; pers. obs.). It is at this time of year that many species use subterranean refugia which form as a consequence of the region's contracting clay soil. The following species all have been directly observed using the extensive network of soil cracks and cavities as refugia (pers. obs.; Turner 1989): Southern Bell Frog *Litoria raniformis, L. tasmaniensis, E. tympanum*, Grass Skink *Lampropholis guichenoti*, Tussock Skink *Pseudemoia pagenstecherii*, Lowland Copperhead *Austrelaps superbus*, *N. scutatus*, *P. flagellum* and *P. t. textilis*. In the cooler months, crevices in basalt exfoliations are exploited by most of these species as well as the Marbled Gecko *Christinus marmoratus*.

Nearly all burrows described in this work were associated with basalt stones (i.e. were constructed beneath or around the edges of stones) but there is no reason why burrows used by reptiles and frogs should not occur more widely within grassland habitat and perhaps be associated with other habitat features (e.g. soil type, elevation, vegetation, etc.). It was, however, neither practical nor desirable to destructively examine the soil layer (away from stones) for burrowing reptiles and frogs in grassland remnants. The extent to which this limitation in detecting burrows affected the frequencies obtained in the results is not entirely clear as burrows associated with stones may be preferred by some species compared to burrows constructed in open ground for several reasons, e.g. (i) their entrances are generally well concealed and may, therefore, provide greater protection from predators and (ii) they are less likely to experience the extremes of temperature, inundation and (low) humidity.

The extent of burrow-use recorded in this work, in some species at least, is significantly underestimated as a consequence of the search methods employed. In particular, the frequency of burrowing in the frogs *N. sudellae* and *L. d. dumerillii* is likely to be significantly underestimated because these species burrow directly into soil away from stones and have closed-entrance burrows that are difficult to detect visually (pers. obs.). I have observed these species only in the weeks following heavy rain, beneath stones while moist conditions persisted there, only to vanish once the soil (beneath stones) dried out again. On a few occasions these species were accidentally unearthed from burrows in grasslands. Interestingly, McCoy (1880) noted that *L. d. dumerillii* habitually buried themselves seven or eight inches under the surface of the light sandy soil of Brighton and other similar localities on the south coast, where they could be dug out any day in considerable numbers. It is likely that both frog species are considerably more common in grasslands than is indicated by searching ground cover, and this is supported by observations of their breeding activity (both eggs and larvae) at a number of grassland sites (pers. obs.). Both species are well adapted to constructing their own burrows due to the possession of an (inner) metatarsal tubercle but, even with this adaptation, burrow construction in clay soil (as well as emergence from burrows) would seem possible only when the soil is sufficiently moist.

The dominant clay soils of the Werribee–Keilor plains are not particularly amenable to burrow construction by many of the reptile and frog species inhabiting the region, as most of these species lack specialised adaptations for either digging or burrowing. It is, therefore, not surprising that the two reptile species that most frequently construct their own burrows do so in loam, rather than in clay soil. The small-scale distributions of the lizards *C. robustus* and *L. bougainvillii* on the Werribee–Keilor plains appear to be closely associated with the occurrence of Corangamite stony loam soil. Both species were recorded on stony rises and at, or near, the top of escarpments where loam soil occurs and were only rarely located on clay soil (see Observations). The fossorial habit of *L. bougainvillii* may explain this preference since (undisturbed) clay soil, irrespective of moisture content, is generally quite stiff and would presumably hinder the movements of this small lizard. The association of *C. robustus* with loam soil might be due, at least in part, to the difficulty this moderately-sized skink (SVL 110 mm) has in constructing burrows in clay soil. It might also be significant that these two skink species are oviparous and bury their eggs in shallow burrows (pers. obs.). Of course there may be other microhabitat features associated with loam soil that makes it preferable for both species. No other reptile or frog species inhabiting the Werribee–Keilor plains appears to show such a strong association with soil type.

Basalt plains herpetofauna that have a natural tendency to burrow, but do so rarely on the plains, should show an increased incidence of burrowing outside the region in soils that are more conducive to burrowing.

Parasuta flagellum is one species which appears to exhibit this pattern, despite its lack of any special adaptations for burrowing. Its commonly cited habit of ' … being often dug out of light sandy soil of gardens from a depth of several inches …' (e.g. Waite 1929; Gow 1976), is attributable to McCoy (1878) who makes this comment in reference to specimens collected from sandy soils at Brighton Beach. *Parasuta flagellum* occur in the coastal heathlands of Altona (Altona Coastal Park), Cheetham Wetlands and Point Cook, which also have sandy soils, and in limited sampling at these sites I have located individuals in burrows in moist sand beneath stones (three of 11 individuals). These observations, combined with those of the species in captivity, suggest that *P. flagellum* has a natural tendency to burrow. That this species rarely burrows in basalt plains grasslands may be attributed to the difficulties of burrowing in clay soil and/or the abundance of alternative refugia.

Other members of the water skink genus *Eulamprus* appear to also use crustacean burrows as refugia. The Alpine Water Skink *Eulamprus kosciuskoi* is described as being a secretive species that usually retreats rapidly into a burrow when disturbed and that

> 'the burrows used by this species appear to be made by the freshwater crayfish (Euastacus) … These burrows are often flooded in winter but it is not known if the Alpine Water Skinks still use them as hibernation sites.'

(Greene and Osborne 1994, p104). The Blue Mountains Water Skink *Eulamprus leuraensis* 'When disturbed … rapidly took shelter either in dense grass tussocks or down holes (possibly yabby burrows) in the peat substrates.' (Shea and Peterson 1985, p. 144). The Eastern Water Skink *Eulamprus quoyii* has been observed using both crustacean and rodent burrows bored into the sides of drainage lines bordering sugar cane fields in north Queensland (pers. obs.). A number of frog species also have been recorded using yabbie burrows e.g. Giant Burrowing Frog *Helioporous australiacus* (Griffiths 1997). Yabbies are well known for their burrowing habit and ability to tolerate long periods of drought by burrowing deep into moist soil (Jones and Morgan 1994). Yabbie burrows on the Werribee–Keilor plains possibly provide moist microhabitats in areas otherwise lacking surface water or moisture and may, therefore, permit both *E. tympanum* and *L. tasmaniensis* to occupy refugia away from riparian zones bordering watercourses. The fact that most of these burrows were beneath stones would aid in reducing evaporative water loss from the burrows. At the site where observations occurred, *E. tympanum* were typically observed using escarpment lining creeks, within approximately 8 m of the water's edge (cf. 25–40 m where burrows were located).

Two basalt plains reptiles have been recorded using spider burrows as refugia: the (presumed locally extinct) Southern Lined Earless Dragon *Tympanocryptis lineata pinguicolla* was noted as 'retreating into small holes, like those of the "Trap-door Spider," in the ground when alarmed' (McCoy 1889: 298). There is a single record of *D. impar* occupying a spider burrow in ACT grasslands (in Smith and Robertson 1999). Ehmann (1992) stated that *D. impar* frequently takes up long-term residence in a spider burrow from which it ambushes prey and where it also lays its eggs; however, neither the circumstances, sample size nor provenance of these interesting observations is indicated. Lucas and Frost (1894: 39) stated in regard to *D. impar* that 'Large numbers were turned up by the pick and shovel in removing the surface soil in the construction of the sewers at Werribee'. Coulson (1990) recorded three other instances of *D. impar* being located in soil on the Werribee–Keilor plains and three separate records of (multiple) specimens from western Victoria being unearthed when ploughing paddocks that had lain fallow for many years or previously had not been cultivated. These observations suggest that subterranean concealment may be common in *D. impar* inhabiting the plains, but whether this is the result of burrowing or the occupation of natural cavities in clay soil is unclear. Wilson and Knowles (1988) recorded this species in mats of dead vegetation and grass tussocks. Both *T. l. pinguicolla* and *D. impar* species also are known to use surface stones as refugia (Lucas and Frost 1894; Coulson 1990; pers. obs.).

The significant association between size-class and burrow construction in *C. robustus* may be a simple function of body size. Adults, being larger, may require the excavation of soil to gain access and/or to create a sufficiently large cavity beneath stones; juveniles may be small enough to access and occupy existing gaps and cavities. Alternatively, burrow construction in adult *C. robustus* may indicate prolonged use of a particular refuge and be associated with the establishment of a territory or home-range. In the Copper-tailed Skink *Ctenotus taeniolatus* from the New England Tablelands region of NSW, both adults and juveniles constructed burrows and both burrow size and structure did not vary between them (Taylor 1984). Conspecific *C. taeniolatus* were rarely found together under the same rock and never were found within the same burrow. Both these observations are at odds with burrow-use observed in *C. robustus* in this work. Taylor (1984) further noted that when inactive in burrows, *C. taeniolatus* were usually in a curled position with the tail bent towards the head, and the fore- and hind-limbs pressed against the body with the front and rear feet resting on the dorsal surface. I frequently have observed the same posture adopted by inactive *C. robustus*. Hawkeswood (2004) observed *C. robustus* using short shallow burrows in soft grey sand beneath concrete slabs at Hastings Point, NSW and noted that their presence in burrows was indicated by the accumulation of scattered beetle remains and a brushed pattern in sand radiating out from the burrow entrance. While adult *C. robustus* burrows from the Werribee–Keilor plains showed signs of frequent use, such as exposed or disturbed soil around the entrance, remains of potential prey were not commonly observed near the burrow entrance.

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Ninety-nine Years Ago

Notes on English and Japanese newts in Victoria

By H. W. Davey, F.E.S.

(*Read before the Field Naturalists' Club of Victoria, 14th Dec,* 1914.)

The larva, on breaking loose from the egg, is rather a helpless creature for some days, and spends most of its time lying on the bottom of the pond, or clinging to some plant or other object in the water. It is at this time that great numbers of them are eaten by the adults of their own and other species, who are most diligent in their search after them.

When disturbed the larva makes a dash away for a short distance before settling down again. Aquatic beetles and their larvae, bugs, and small fish also feed largely upon them at this stage, but the newt larvae soon gain strength and swimming powers, and with greater ease escape their enemies, and can more safely emerge from the cover of the waterplants into more open water. Their growth is now rapid. The length of time taken by *M[olge] cristatus* to mature from hatching to the lung-breathing state in Victoria varies from 93 to 108 days.

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